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Tile and Surface Drainage of Clay Soils

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V. Corn, Oats, and Soybean Yields (1973-80)
VI. Water Quality
VII. Cross Moling Over Tile Drains

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ON THE COVER: General view showing drainage sump, irrigation pipe, and corn plots (in background).

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INTRODUCTION

This report summarizes the data collected for the 10-year period, 1973-1982, from a 25-year field experiment at the North Central Branch, Ohio Agricultural Research and Development Center, near Sandusky. The predominant soil type is Toledo silty clay, typical of the soils in the lake region of the North Central United States. Research Bulletin 935 (19) reported hydrologic data for the first 3 years, 1959-61, with a tall fescue crop. Hydrologic data and corn, soybean, and oat yields for the 11-year period, 1962-72, were given in Research Bulletin 1081 (14). This report covers primarily the final 10 years of crop yields and drain flow from the experiment, as well as some long-term summaries. All research was terminated in 1982.

A number of interim reports were prepared during the period, 1973-80, and will be reviewed briefly. A simple, low-cost, proportional sampler was designed to collect both the tile and surface water (8). Schwab *et al.* (13) reported that for conventional tillage, corn yields were negatively correlated to drain flow for the months of May, June, and July. For 1969-71, plant populations for corn were reduced as much as 40% by no tillage, but yields were reduced less than 20%. Using a water management model, DRAINMOD, developed in North Carolina, Hardjoamidjojo *et al.* (3) computed stress day indexes for a 12-year period (through 1979 year) and related these to corn yields from this experiment. This index is a measure of the water table duration less than 1-foot soil depth and includes a crop susceptibility factor related to stage of plant growth. The regression model of the Ohio data showed a strong relationship between relative corn yield and the stress day index. Predictions were in good agreement with results from other experiments in Iowa and India.

During 1969, the undrained plots were drained to evaluate the performance of shallow, small-diameter corrugated tubing as subsurface drains. Fausey and Brehm (2) reported that small diameter-shallow (2-inch diame-

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ter and 1.6-ft depth) drains at narrow spacing (20 ft) were hydraulically and structurally satisfactory 5 years after installation. Fausey (1) summarized the flow from these shallow drains over 10 years and showed that the total water removed by the shallow drains was similar to that removed by the deeper drains. Later, by retrenching over these shallow drains and backfilling the trench with gravel to the bottom of the plow layer, flow rates were increased by a factor of 2 to 3 during ponding on the surface (5, 22, 23). These rates remained high after 3 years. Without ponding, flow rates were not increased by the permeable backfill.

Comparisons of tile flow at the 3rd (1960) and 18th year (1975) after installation with the same type of crop and the same rate and volume of irrigation showed that peak tile flow and flow volume did not change significantly during this 15-year period (7). The data showed a slight improvement with time for the combination tile and surface drained system. The tiled plots were also used to obtain hydraulic conductivity and soil porosity data for prediction of tile spacing (15). For the deep (3 ft) tile, the measurements showed the average rate of drawdown to be about 0.8 ft per day for the existing 40-ft spacing. This rate is considered satisfactory for field crops. For the shallow (1.5 ft) tile, the drawdown rate was about 0.5 ft per day for the 20-ft spacing.

Based on 15 major flow events, McLean and Schwab (6) concluded that tile drainage reduced flood peak flows an average of 32% compared to surface runoff where no tile was installed. Using all flows from 1958-75 in excess of a 5.9-inch per day rate, they found that the number of floods was reduced 46% by tile drainage.

Predicted and measured drainage volumes were compared using DRAINMOD for 8 years of record by Skaggs *et al.* (21). Plots were in corn for all 8 years. Comparisons were made for surface drainage alone, tile drainage alone, and the combination tile-surface drainage plots for the months April through September. Predicted volumes were in good agreement with measured volumes for all three drainage treatments.

Hundal *et al.* (4) studied the soil properties in all of the plots 16 years after the drains were installed. Tile drained plots had greater soil hydraulic conductivity, less unconfined compressive strength, and less surface crust resistance than the untiled plots. Soil bulk density was decreased and soil porosity was increased by tile drainage, but to a lesser extent. These soil measurements as well as crop yields indicate that the drainage systems in increasing order of benefits are undrained A, surface drained B, tile drained C, and combination of tile and surface drainage D.

Water quality was measured from the tile drained, surface drained, and shallow tile drained plots for the period 1969-79. Most of the data was reported by Schwab and McLean (10, 11), Schwab and Logan (9), and Schwab *et al.* (12, 16, 20). For some years flow records and samples were not taken during the winter months. Year-to-year variation was a dominant factor, mostly because of varying precipitation, but crop effect was also important. Tile flow for the period of record was slightly more than surface runoff, but sediment, phosphorus, and potassium losses were considerably less in the tile flow than in the surface runoff. Only nitrate losses were higher from the tile. Compared to conventional tillage, no tillage greatly reduced sediment losses, but pesticide losses were higher. Shallow drains reduced sediment losses over a 6-year period about 50% compared to the deep tile. The highest sediment losses for the period of record occurred when the plots were bare which coincided with years of high rainfall.

FIELD LAYOUT AND PROCEDURES

Cropping and Tillage Practices

Soil and crop management practices for 1973-80 are summarized in Table 1. In 1973 the plots were bare most of the year because of failure of the alfalfa/timothy seedings. The purpose of the meadow crop was to improve organic matter content and equalize plot differences, especially in the shallow drained plots (E) which were previously undrained and had poor soil structure. During 1976-80 the plots were divided into thirds to provide yields for each of three crops each year. Replications 1 and 3 were sprinkler irrigated and replications 2 and 4 were not. The purpose of the irrigation split was to obtain data to adjust the previous crop yields for irrigation. Irrigation water was added to produce wet conditions and not to supply

TABLE 1.—Soil and Crop Management Practices, 1973-80.

Year	Crop	Total Irrigation Water in Inches*	Fertilizers Applied in Lb/Acre N	P	K	Remarks
1973	Bare	1.1	0	150	282	Seeded in fall
1974	Alfalfa/ Timothy	0	51	22	124	No harvest
1975	Alfalfa/ Timothy	3.9	67	0	0	No harvest
1976	Corn	6.0	230	13	25	Split plots
	Oats	6.0	12	21	40	
	Soybeans	6.0	0	140	76	
1977	Corn	6.0	200	18	33	Split plots
	Oats	6.0	30	13	25	
	Soybeans	6.0	0	34	65	
1978	Corn	5.2	200	20	37	Split plots
	Oats	5.2	30	13	25	
	Soybeans	5.2	0	34	85	
1979	Corn	6.0	200	22	42	Split plots — oats not planted
	Soybeans	6.0	0	22	42	
1980	Corn	6.6	200	22	42	Split plots — oats area planted to corn
	Soybeans	6.6	0	22	42	

*Only replicates 1 and 3 were irrigated, except in 1975 when all four replicates were irrigated.

deficient moisture. In 1979 oat plots were not planted because of excess wetness.

Irrigation Scheduling

Irrigation amounts were varied from year to year to meet the objectives of the experiment. In 1975, 3.9 inches were applied for flow comparison with previous years to evaluate the effect of time on hydrologic performance of tile drains. Normally, two 3-inch applications were made in June and July of each year (1976-80). The amount was adjusted slightly in some years because of technical problems or differences in antecedent soil moisture. Rate of application was about 0.23 iph for 13 hours as in previous years (1962-72). Eight plots were irrigated at one setting with 100 sprinklers at a spacing of 40 by 50 feet. Irrigation scheduling, soil temperature, and antecedent soil moisture prior to irrigation are given in Table A1. Precipitation and irrigation by months and years are shown in Table A2.

IV. HYDROLOGIC PERFORMANCE WITH FIELD CROPS

Monthly and seasonal tile and surface flows for 1973-80 from rainfall and irrigation are tabulated for each replication in Appendix B. Similar data for 1962-72 can be found in Schwab *et al.* (14). Flows were recorded from four replications from 1973-75 and from two replications (1 and 3) from 1976-80. Least squares means for the flows from rainfall are shown in Table 2 and Figure 1 for the 8-year period (1973-80). Weighted average monthly and seasonal flows for the 19-year period (1962-80) are shown in Table 2 for surface only and tile (deep). Seasonal drain flows increased in the order surface B, deep tile C, and shallow tile E. The combination tile and surface drainage D flows were taken only in 1975. The highest average monthly flows for 1973-80 were in March and the lowest in July, August, or September. Although no major storms occurred during the 1973-80 period, the seasonal rainfall was above the 60-year average of 22.07 inches in 5 of the 8 years. Tile flow and surface runoff for the irrigation periods only are shown in Table 3. Only 3% more flow (33 vs. 30% applied) was removed by the tile than ran off the surface for the same amounts applied. From small natural storms the percentages would be lower, although for high intensity storms they could be higher.

An analysis of variance of the data in Table 2 showed that the flows (1973-80) were not significantly different among the three drainage systems for all months. Seasonal tile flows from both shallow and deep tile were higher than the surface flow, but not significantly different. As shown for irrigation in Table 3, average tile flow was also greater than surface runoff.

The weighted average of least squares means flows (Table 2) for the 19-year period (1962-80) were higher, but in the same order for surface runoff or deep tile flow as for the 8-year period (1973-80). Comparison of monthly flows for these two periods showed that the greatest difference was in July. The high July average for the 19-year record reflects very large storms in 1966 and 1969 (over 100-year return period). Flows for the 11-year period (1962-72) were 36% greater for surface runoff and 22% greater for tile flow compared to the 8-year period (1973-80).

TABLE 2.—Monthly and Seasonal Flows for Drainage Systems from Rainfall with Conventional Tillage.

Drainage	Flow Depth in Inches							
	March	April	May	June	July	August	Sept.	Seasonal Total
8-Year Period (1973-80) (Least squares means)								
Surface	1.41	0.60	0.22	0.57	0.26	0.13	0.11	3.30
Tile (deep)	1.26	0.77	0.49	0.82	0.27	0.15	0.17	3.93
Tile (shallow)†	1.60	1.03	0.52	0.70	0.29	0.44	0.40	4.98
Drainage Means	*	*	*	*	*	*	*	*
19-Year Period (1962-80)‡								
Surface	0.80	0.55	0.54	0.67	1.01	0.16	0.25	3.98
Tile (deep)	1.13	0.88	0.87	0.94	0.97	0.14	0.25	5.18
12-Year Period (1962-1972, 1975) (Weighted average of least squares means)								
Surface + Tile	0.85	0.89	1.02	0.99	1.71	0.13	0.29	5.92
1-Year Period (1975)								
Surface + Tile	0.67	0.20	0.42	0.08	0	0.07	0.03	1.47

*Not significantly different at the 95% level

†Flow only for 6-year period (1975-80)

‡Weighted average of least squares means for 1962-72 period and for 1973-80 period [For 1962-72 data, see Table 2, Res Bull 1081(14)]

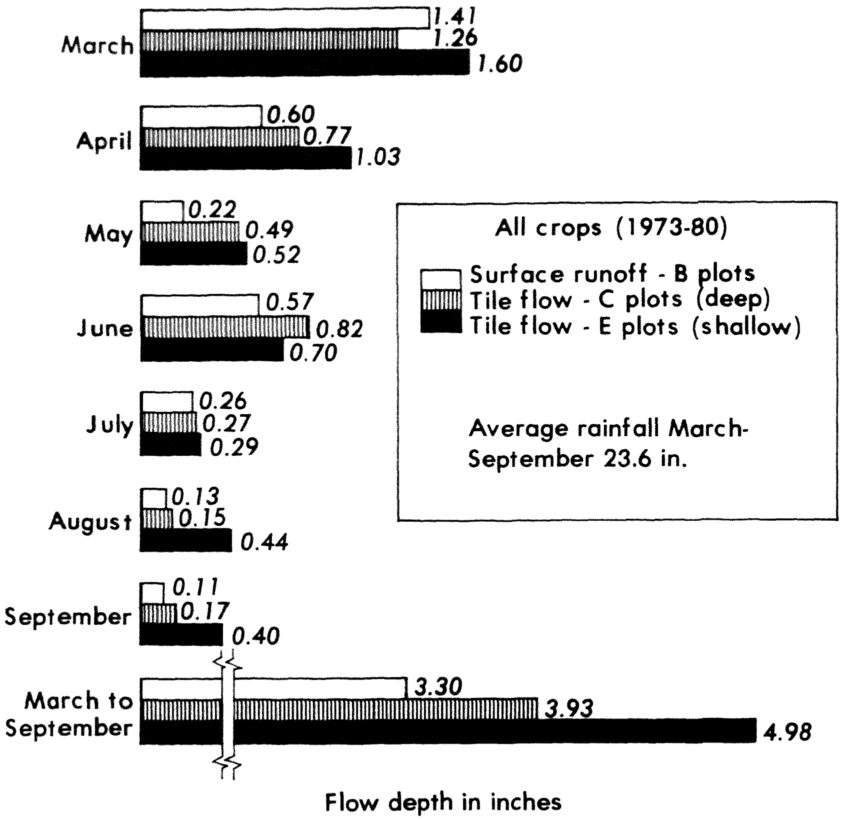

FIG. 1.—Weighted average monthly and seasonal flows by least squares means for the 8-year period, 1973-80.

TABLE 3.—Tile Flow and Surface Runoff from Irrigation, 1975-80.

	Irrigation Depth in Inches (No. of Applications)		Tile Flow in in Inches (B plots) Av.	Percent Applied	Surface Runoff Inches (C plots) Av.	Percent Applied
1975	3 9	(1)	1 93	49	1 98	51
1976	6 0	(2)	1 90	32	1 68	28
1977	6 0	(2)	2 33	39	0 97	16
1978	5 2	(2)	2 01	39	1 41	27
1979	6 0	(2)	1 73	29	1 97	33
1980	6 6	(2)	1 18	18	1 96	30
Av	5 6		1.85	33	1 66	30

V. CORN, OATS, AND SOYBEAN YIELDS

Crop yields for all years (1962-80) for the five drainage systems were analyzed and are reported in Tables 4, 5, 6, and 7. Years of record for corn, oats, and soybeans are 13, 5, and 6, respectively. Yields for drainage systems B, C, and D were obtained for all years shown in the tables. The undrained plots A were drained in late 1969 and changed to tile (shallow) E thereafter. The drains in the E plots were 2-inch diameter tubing, but will be referred to as tile in this report.

Corn yields and mean stands are shown in Table 4 for the first year in corn (following some other crop) and for the second or more years of corn in sequence. All yields were adjusted for irrigation by statistical methods to relate more closely to natural rainfall conditions. Adjustment for stand can be justified only if the stand variable can be attributed to factors other than drainage. Most of the stand effect is believed to be due to drainage.

Without correction for stand, first year corn averaged about 29 bu/A more than second year corn. Stands were higher for first year corn, except for the A treatment. For all 13 years of corn, yields increased in the order undrained A, surface B, tile (shallow) E, tile (deep) C, and surface plus tile drainage D systems. Stands were nearly in the same order. When adjusted for irrigation and stand, yields were about 15 bu/A higher for the undrained treatment than when adjusted for irrigation only, and the difference was less than 4 bu/A for the other drainage systems. This difference indicates that poor drainage has the greatest effect on stand. The standard deviation and coefficient of variation for stand (Table 5) are high for undrained and surface drainage compared to the three other systems. The variation in corn yield from year to year is about 33% for surface drainage and 19% for the three other tile drainage systems shown in Table 5. Smaller variations for tile are a benefit to the farmer because of less variability in income. This benefit is in addition to increased yield.

Unadjusted crop yields by years are shown in Figure 2. The yields with tile are an average of the two plots (C, D). This average is more representative of most farm fields than either drainage treatment in the experiment because farm surface drainage generally is better than in C and not as good as in the D plots. For the above reason, yields shown are not the same as in the tables, but for comparative purposes they show the same pattern. Differences between first and second year corn yields are evident as well as a general trend of increasing corn yields from 1962 to 1980. An economic analysis of these yields by Schwab *et al.* (17, 18) showed that the benefit-cost ratio for corn was 2.2 for surface drainage and 2.0 for tile. Similar benefit-cost ratios for soybeans were 2.1 and 1.2, respectively. The higher ratios for surface drainage are primarily due to the lower investment cost compared to tile drainage.

Oat yields and coefficients of variation shown in Table 6 are in the same order by drainage systems (A, B, E, C, and D) as for corn. The coefficients of variation decrease with increased drainage. The average coefficient of variation for oats in the three tiled treatments (C, D, E) was 43% compared

TABLE 4.—Corn Yields and Stands by Drainage Systems (Least Squares Means for Yields).

Year in Corn (Years of Record for B, C, D)	Years of Record	Drainage Treatment		Corn Yield in Bu/A Adjusted for Irrigation	Mean Stand in 1,000 Plants/A
First* (7)	1962, 1967 1976-80	A	Undrained	63.6	10.4
		B	Surface	103.5	19.0
		C	Tile (deep)	125.5	22.2
		D	Surface + Tile	130.5	23.0
		E	Tile (shallow)	113.3	22.0
Second or More† (6)	1963-64 1968-71	A	Undrained	56.6	14.1
		B	Surface	70.7	18.7
		C	Tile (deep)	97.6	20.6
		D	Surface + Tile	105.0	20.2
First and Second or More (13)	1962-64 1967-71 1976-80	A	Undrained	59.9	13.1
		B	Surface	91.7	18.9
		C	Tile (deep)	115.5	21.6
		D	Surface + Tile	121.4	22.0
		E	Tile (shallow)	111.0	22.0
				Adjusted for Irrigation and Stand	**Adjusted to Average Stand**
First and Second or More (13)	1962-64 1967-71 1976-80	A	Undrained	74.4	21.1
		B	Surface	94.6	21.1
		C	Tile (deep)	112.5	21.1
		D	Surface + Tile	117.5	21.1
		E	Tile (shallow)	108.3	21.1

Note Plot A for years 1962-69 and Plot E for years 1970-80
*First year in corn preceded by some other crop
†Second year in corn preceded by corn

to 19% for corn. Average oat yields for tile were 21 bu/A higher than for surface drainage alone. This difference is probably due to the earlier planting date for oats when wetness is more likely to occur. In some years oats were not planted due to wetness.

TABLE 5.—Standard Deviation and Coefficient of Variation of Corn Yields and Stands Due to Yearly Effects (1962-64, 1967-71, 1976-80).

	Corn Yield		Corn Stand	
Drainage Treatment	Standard Deviation Bu/A	Coefficient of Variation In Percent	Standard Deviation 1,000 Plants/A	Coefficient of Variation In Percent
A Undrained	26.1	45.8	5.4	41.2
B Surface	30.4	33.2	5.5	29.3
C Tile (deep)	21.1	18.3	4.5	20.8
D Surface + Tile	20.9	17.2	4.1	18.6
E Tile (shallow)	23.3	20.4	4.5	20.7

Note: Yields for all 13 years of record adjusted for irrigation but unadjusted for stand.

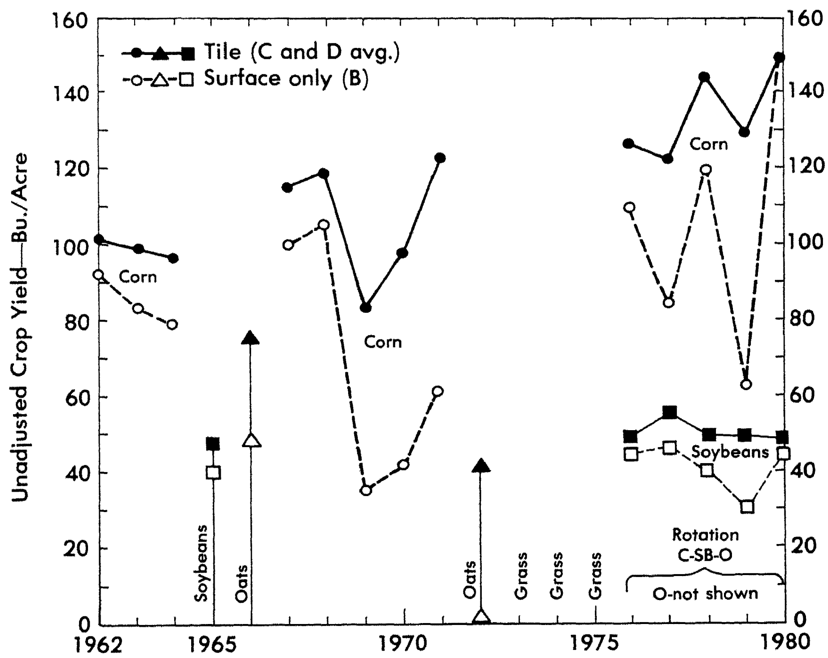

FIG. 2.—Unadjusted crop yields for the tile (C and D average) and surface drainage (B).

Soybean yields and coefficients of variation shown in Table 7 are in the same order by drainage systems (A, B, E, C, and D) as for corn. The average yields increase and the coefficients of variation decrease with increased drainage. The average coefficient of variation for soybeans for the three tiled treatments was about 10%, the lowest of the three crops. Average soybean yields for the three tiled treatments were about 7 bu/A higher than for surface drainage alone. Lower response to drainage and smaller coefficients of variation are due in part to the later planting date for soybeans than for oats and corn.

TABLE 6.—Oat Yields by Drainage Systems (Least Squares Means) (1966, 1972, 1976-78).

Drainage Treatment		Crop Yield in Bu/A*	Standard Deviation in Bu/A	Coefficient of Variation in Percent
A	Undrained	4.4*	0	0
B	Surface	36.5†	25.9	70.9
C	Tile (deep)	59.7	24.8	41.6
D	Surface + Tile	67.8	23.2	34.3
E	Tile (shallow)	43.9	23.7	52.7

*1966 only year of record.
†1972 not planted due to wetness.

TABLE 7.—Soybean Yields by Drainage Systems (Least Squares Means) (1965, 1976-80).

Drainage Treatment		Crop Yield in Bu/A*	Standard Deviation in Bu/A	Coefficient of Variation in Percent
A	Undrained	4.4	1.7	46.4
B	Surface	41.7	8.4	20.2
C	Tile (deep)	49.1	5.3	10.8
D	Surface + Tile	51.7	4.2	8.1
E	Tile (shallow)	43.9	5.3	12.1

*All yields have been adjusted for irrigation.

VI. WATER QUALITY

Since detailed records of water quality have been reported in previously listed references, only summaries by groups of years are presented. As shown in Table 8, no till corn reduced sediment losses to about 25% of those for conventional tillage. Nitrate nitrogen losses were also reduced slightly.

Annual losses of sediment and nutrients are shown in Table 9. All losses (1974-79) were somewhat higher for the deep compared to shallow tile, which can be only partly explained by the greater flow. Sediment losses for surface runoff (1969-79) are much higher than from tile, but nitrate nitrogen losses are lower. The high tile sediment losses for the 1969-79 period compared to the 1974-79 period were due to several high annual losses during the 1969-73 years. The highest year of record was 1972 when the loss was 4,825 lb/A for the deep tile. The highest surface runoff loss was 8,082 lb/A, also in 1972. The oats stubble in 1972 was plowed under in August prior to alfalfa-grass seeding in September. The combination of bare soil and the highest annual precipitation (45.4 inches) for the 1969-79 period was the major cause of these high losses. For flat land these losses are unusually high.

The percentages of annual losses for the growing season are shown in Table 10. Except for total P, all percentages are more than 58%, which is also the time percentage for the growing season of the year. The percentage losses from surface runoff are slightly higher than those from tile.

Water samples were evaluated for pesticide losses during the 1969-71 growing seasons. Losses in percent of amount applied and concentrations of pesticides, sediment, and nutrients are shown in Tables 11 and 12. The amounts of material applied for conventional and no tillage were essentially the same for all years. With few exceptions, 90% or more of the pesticide losses were during the 7-month growing season. These percentages are higher than those shown in Table 10 for sediment and nutrients. In general, pesticide losses were higher for no tillage even though applications were the same. Losses would tend to be even higher with typical no tillage practices because greater amounts of pesticides are usually needed to control weeds and insects. Concentrations of constituents in drainage water are given in Table 12 as these may be of interest for wildlife and aquatic plants and for domestic use.

TABLE 8.—Tile Water Quality by Tillage Method (1969-71).

Crop, Tillage	Av. Drain Flow, Inches	Average Annual Losses in Lb/A			
		Sediment	NO_3-N	Total P	Soluble K
Corn, conventional	5.5	1021	19.0	0.6	6.7
Corn, no tillage	6.2	250	15.9	0.5	3.9

TABLE 9.—Tile Water Quality by Drainage System.

Drainage Treatment	Plot	Years of Record	Av. Drain Flow, Inches	Average Annual Losses in Lb/A			
				Sediment	NO_3-N	Total P	Soluble K
Tile (deep)	C	1974-79	7 1	373	11 7	1 0	10 3
Tile (shallow)	E	1974-79	6 3	176	9 3	0 7	7 8
Surface	B	1969-79	7 0	2112	9 9	1 9	28 1
Tile (deep)	C	1969-79	7 6	1284	15 5	1 1	20 1

Note Crops varied, but were the same for each treatment for years shown

TABLE 10.—Percentage of Annual Losses from Drains During the Growing Season (April through October).

Drainage Treatment	Plot	Years of Record	Sediment	NO_3-N	Total P	Soluble K
Tile (shallow)	E	1974-78	60%	60%	43%	58%
Tile (deep)	C	1969-78	72	57	50	62
Surface	B	1969-78	74	71	65	61

Note Crops varied but were the same for each treatment for years shown From Schwab *et al* (12)

TABLE 11.—Characteristics and Constituents in Drainage Water and on Sediment from Rainfall (Averages for 1969-71 Growing Seasons for Corn).

	Conventional Tillage		No Tillage	
	Tile	Surface	Tile	Surface
Pesticides	Average Losses in Percent of Applied			
Atrazine	2 8	5 7	5 6	6 9
Dicamba	2 0	4 0	7 3	7 2
Aldrin and Dieldrin	<0 01*	<0 01*	None Applied	
Heptachlor and Heptachlor Epoxide	<0 01	<0 01	<0 01*	<0 01*
Electrical Conductivity, in micromhos/cm	1062	849	729	857
pH	7 1	6 7	7 1	6 9
Av seasonal flow, inches	5 1	4 6	5 6	3 8

*Average for 1970-71 only

Note Average applications of atrazine, 3 4 lb/A, dicamba, 0 12 lb/A, aldrin, 4 7 lb/A and heptachlor, 1 6 lb/A

From Schwab *et al* (20)

TABLE 12.—Concentrations of Constituents in Drainage Water from Rainfall (Averages for 1969-71 Growing Seasons for Corn).

	Weighted Averages in mg/liter			
	Conventional Tillage		No Tillage	
Material	**Tile**	**Surface**	**Tile**	**Surface**
Sediment	880	1238	177	277
Dissolved Solids	2204	1075	1082	1062
Nitrogen NO_3-N	15 7	18 1	8 6	14 5
Phosphorus — P	0 6*	5 0*	0 5*	1 8*
Potassium — K	5 1*	11 7*	3 0*	17 0*
Atrazine	0 073	0 105	0 102	0 174
Dicamba	0 001	0 002	0 004	0 005
Aldrin and Dieldrin	0 00006*	0 00004*	None Applied	
Heptachlor and Heptachlor Epoxide	0 00001	0 00002	0 00002*	0 00003

*Average for 1970-71 only
From Schwab *et al* (20)

VII. CROSS MOLING OVER TILE DRAINS

Mole drains were installed in plots 1C (replicate 1, deep tile) and 1D (surface plus tile drainage) in April 1981 with a New Zealand mole plow at a depth of about 20 inches. This depth was slightly above the existing tile drains, but no connection was made between the moles and the drains. The mole drains were spaced about 6 feet apart, perpendicular to the tile lines.

A total of 148 peak flow rates (1972-80) from similar drainage treatment plots, 3C and 3D, were compared to the moled plots 1C and 1D, respectively. The peak flow rates from the two sets were nearly the same before cross moling. After moling, 34 peak flows (1981-82) were compared. The moled plots (1C and 1D) showed an average increase in peak rates of 0.13 inch per day compared to the pretreatment flows. Differences were not consistent for the two drainage treatments. It was concluded that mole drains were not sufficiently effective for the first 2 years to justify their cost of installation.

SUMMARY

Least squares means drain flow for the growing season (March-September) from rainfall for 1973-80 increased in the order by drainage: surface, deep tile, and shallow tile. The highest average monthly flows were in March for the 8-year period, 1973-80.

For the period of record, 1962-80, corn yields were obtained for 13 years, oats for 5 years, and soybeans for 6 years. For all three crops the least squares means yield increased in the following order: undrained, surface, shallow tile, deep tile, and combination surface plus tile drainage. This sequence is in about the same order as the drain flow, indicating that yields are related to degree of drainage. Corn stands were in nearly the same order as yields. First year corn yields averaged about 29% higher than second year (corn after corn) corn yields (Table 4). Correcting for corn stand reduced corn yields only a few bushels per acre for the better drainage systems. Annual variation of corn yields was about 19% for the three tile drainage systems compared to 46% and 33% for the undrained and surface drained treatments (Table 5), respectively.

Oats responded to tile drainage with an average increase of 21 bu/A over surface drainage yields (Table 6). The annual variation was 43% compared to 19% for corn. In the surface drained plots, oats were not planted in 1972 due to wetness, which is reflected in the yields shown.

Soybean yields for the three tile drainage treatments averaged about 7 bu/A higher than surface drainage yields (Table 7). The annual variation for these treatments was only 10%, the lowest of the three crops.

In general, quality of water from tile drains is better than from surface drains. No tillage for corn reduced sediment losses to about 25% of that for conventional tillage, but atrazine and dicamba pesticide losses greatly increased (Tables 8 and 11). Nitrate nitrogen losses (1969-79) from tile drains averaged 15.5 lb/A compared to 9.9 lb/A in surface runoff (Table 9). Sediment, total phosphorus, soluble potassium, atrazine, and dicamba losses during the growing season were greater in surface runoff than in tile flow (Tables 9 and 11). Only nitrate losses were higher from tile flow. In general, more than 58% of the annual losses of sediment and nutrients occurred during the growing season, April through October (Table 10).

Mole drains at 6-foot intervals crossing tile drains did not increase peak tile flow rates for the first 2 years after installation. They deteriorated rapidly and are not considered cost effective.

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APPENDIX A
PRECIPITATION, IRRIGATION, AND SOIL PROPERTIES

TABLE A1.—Irrigation Scheduling, Soil Temperature, and Antecedent Moisture by Drainage Treatment.

Test No.	Year	Date Irrigation Start-End	°F. Soil Temperature 8-Inch Depth Min.-Max.	Irrigation in Inches	Av. Antecedent Moisture Content at 6-Inch Depth in Percent by Weight — Drainage Plots B	C	D	E
26	1973	9/12-9/13	62-65	1 0				
27	1974	None						
28	1975	5/13-5/15	53-56	3 9	30 1	26 9	27 8	2[illegible]9
29	1976	6/6-6/8	62-67	3 0				
30	1976	6/21-6/23	63-66	3 0				
31	1977	6/2-6/3	58-60	3 0		26 8*		28 4*
32	1977	6/22-6/23	63-66	3 0		21 5*		20 1*
33	1978	6/12-6/13	61-64	2 6				
34	1978	6/22-6/23	64-66	2 6		20 3*		27 8*
35	1979	6/4-6/5	58-60	3 0				
36	1979	7/2-7/3	61-62	3 0				
37	1980	6/9-6/10	58-60	3 5				
38	1980	6/25-6/26	62-64	3 1				

*Taken in replicate 1 only

TABLE A2.—Precipitation and Irrigation Record.

	Precipitation or Irrigation ( ) in Inches							
Month	**1973**	**1974**	**1975**	**1976**	**1977**	**1978**	**1979**	**1980**
Jan	1 31	1 98	2 26	3 02	1 60	4 10	1 92	0 80*
Feb	0 54	1 74	2 39	3 14	1 75	0 32	1 19	1 10*
March	4 34	2 85	2 07	3 08	4 22	2 65	1 91	3 28
April	2 92	2 30	1 73	1 82	3 44	3 98	4 28	1 65
May	4 14	3 91	2 60	3 38	2 26	4 21	4 27	2 77
			(3 90)					
June	8 22	5 06	4 85	3 46	5 62	3 42	4 12	2 76
				(6 00)	(6 00)	(5 20)	(2 97)	(6 57)
July	5 54	1 06	1 01	2 03	4 63	2 21	2 40	3 61
							(3 00)	
August	1 22	4 53	6 96	2 50	4 45	3 34	3 81	4 13
Sept	1 43	1 38	2 51	6 66	5 42	2 48	1 37	2 92
	(1 00)							
Oct	2 71	0 47	2 64	2 05	1 29	2 39	1 80	1 40*
Nov	2 59	3 36	1 35	0 39	2 26	1 81	3 58	1 10*
Dec	3 13	2 82	2 76	1 18	3 57	2 75	2 42	1 70*
Total Rainfall (March-Sept)	27 81	21 09	21 73	22 93	30 04	22 29	22 16	21 12
Total Precipitation (Jan -Dec)	38 09	31 46	33 13	32 71	40 51	33 66	33 07	27 22
Total Irrigation	1 00	0	3 90	6 00	6 00	5 20	5 97	6 57
Total Precipitation and Irrigation	39 09	31 46	37 03	38 71	46 51	38 86	39 04	33 79

*Estimated from Sandusky Climatological Data, Ohio

APPENDIX B
TILE AND SURFACE FLOW

TABLE B1.—Monthly Tile Flow and/or Surface Runoff by Plots and Years (Rainfall and Irrigation) (1973-80).

1	2	3	4	5	6	7	8	9	10	11	12	13
73	1	1	1	0	1 438	.423	092	.901	.710	.000	.000	3.564
73	1	2	1	0	1.217	.414	.082	1.052	.508	.000	.000	3.273
73	1	3	1	0	1.239	.301	.041	1.099	.832	.000	.112	3.624
73	1	4	1	0	1.188	.162	048	.985	.771	.001	.123	3.278
73	3	1	1	0	1.591	.679	1.292	3.005	.935	.003	.031	7.536
73	3	2	1	0	2.949	.639	.549	2.101	.753	.000	.000	6.991
73	3	3	1	0	1.170	.540	.666	3.040	.752	.001	.149	6.318
73	3	4	1	0	1.118	.070	.010	1.816	.807	.000	.188	4.009
74	1	1	1	0	2.488	737	000	.679	.000	.000	.000	3.904
74	1	2	1	0	2.423	1.093	.000	.437	.000	.000	.000	3.953
74	1	3	1	0	1.472	.605	.038	.554	.000	.000	.000	2.669
74	1	4	1	0	1.780	.647	.000	.463	.000	.000	.000	2.890
74	3	1	1	0	1.804	1.344	.045	.465	.000	.000	.000	3.658
74	3	2	1	0	2.261	.584	.000	.562	.000	.000	.000	3.407
74	3	3	1	0	1.693	1.015	.020	.723	.000	.000	.000	3.451
74	3	4	1	0	1.429	.826	.021	.661	.000	.000	.000	2.937
75	1	1	1	0	.310	.000	.020	.000	.000	.070	.030	.430
75	1	1	1	1	.000	.000	2.010	.000	.000	.000	.000	2.010
75	1	2	1	0	.420	.000	.110	.000	.000	.450	.140	1.120
75	1	2	1	1	.000	.000	2.590	.000	.000	.000	.000	2.590
75	1	3	1	0	.330	.000	.040	.000	.000	.170	.060	.600
75	1	3	1	1	.000	.000	1.770	.000	.000	.000	.000	1.770
75	1	4	1	0	.390	.010	.080	.230	.000	.900	.230	1.840
75	1	4	1	1	.000	.000	1.920	.000	.000	.000	.000	1.920
75	2	1	1	0	.850	.270	.190	.000	.000	.060	.080	1.450
75	2	1	1	1	.000	.000	1.530	.000	.000	.000	.000	1.530
75	2	2	1	0	.340	.340	.970	.160	.000	.000	.000	1.810
75	2	2	1	1	.000	.000	1.290	.000	.000	.000	.000	1.290
75	2	3	1	0	.434	.343	.000	.717	.000	.000	.000	1.494
75	2	3	1	1	.000	.000	.780	.000	.000	.000	.000	.780
75	2	4	1	0	.000	.000	.000	.030	.000	.100	.000	.130
75	2	4	1	1	.000	.000	1.010	.000	.000	.000	.000	1.010

Column	Code
1	Year, last two digits
2	Drainage source 1 surface flow, only (B) 2 surface flow, combination system (D) 3 tile flow, only (C) 4 tile flow, combination system (D) 5 plastic tubing, only (E)
3	Replication number
4	Tillage 0 no tillage 1 conventional, fall plowing, spring disking and planting
5	Water source 1 irrigation, sprinkling 0 rainfall
6-12	Flow depth in inches by months (March through September)
13	Flow depth in inches, March to September total

TABLE B1 (continued).—Monthly Tile Flow and/or Surface Runoff by Plots and Years (Rainfall and Irrigation) (1973-80).

1	2	3	4	5	6	7	8	9	10	11	12	13
75	3	1	1	0	.577	.000	.277	.243	.000	.351	.057	1.505
75	3	1	1	1	.000	.000	2.369	.000	.000	.000	.000	2.369
75	3	2	1	0	.246	.016	.062	.048	.000	.373	.072	.817
75	3	2	1	1	.000	.000	1.486	.000	000	.000	.000	1.486
75	3	3	1	0	.348	.124	.172	.058	.000	.261	.068	1.031
75	3	3	1	1	.000	.000	1.479	.000	.000	.000	.000	1.479
75	3	4	1	0	.109	.000	.094	.260	.000	1.186	.345	1.994
75	3	4	1	1	.000	.000	1.120	.000	.000	.000	.000	1.120
75	4	1	1	0	.273	.000	.038	.019	.000	.009	.000	.339
75	4	1	1	1	.000	.000	.950	.000	.000	.000	.000	.950
75	4	2	1	0	.291	.000	.036	017	.000	.018	.007	.369
75	4	2	1	1	.000	.000	.669	.000	.000	.000	.000	.669
75	4	3	1	0	.244	.000	.031	.011	.000	.011	.000	.297
75	4	3	1	1	.000	.000	1.058	.000	.000	.000	.000	1.058
75	4	4	1	0	.265	.000	.047	.013	.000	.013	.020	.358
75	4	4	1	1	.000	.000	1.207	.000	.000	.000	.000	1.207
75	5	1	1	0	1.159	.014	.322	.234	.000	1.805	1.071	4.605
75	5	1	1	1	.000	.000	2.201	.000	.000	.000	.000	2.201
75	5	2	1	0	.591	.010	.163	.217	.000	1.688	.825	3.494
75	5	2	1	1	.000	.000	.939	.000	.000	.000	.000	.939
75	5	3	1	0	.681	.027	.319	.353	.000	2.075	1.051	4.506
75	5	3	1	1	.000	.000	1.476	.000	.000	.000	.000	1.476
75	5	4	1	0	.488	.000	.000	.000	.000	.000	.000	.488
75	5	4	1	1	.000	.000	.738	.000	.000	.000	.000	.738
76	1	1	1	0	.770	.000	.140	.830	.000	.000	.350	2.090
76	1	1	1	1	.000	.000	.000	1.530	.000	.000	.000	1.530
76	1	3	1	0	.550	.000	.090	.820	.000	.000	.000	1.460
76	1	3	1	1	.000	.000	.000	1.670	.000	.000	.000	1.670
76	3	1	1	0	.426	.035	.120	.442	.000	.000	.147	1.170
76	3	1	1	1	.000	.000	.000	1.797	.000	.000	.000	1.797
76	3	3	1	0	.434	.000	.132	.442	.000	.000	.224	1.232
76	3	3	1	1	.000	.000	.000	1.870	.000	.000	.000	1.870
76	5	1	1	0	.974	.019	.525	2.600	.000	.000	.855	4.973
76	5	1	1	1	.000	.000	.000	1.122	.000	.000	.000	1.122
76	5	3	1	0	.578	.035	.393	.801	.000	.000	.604	2.411
76	5	3	1	1	.000	.000	.000	1.990	.000	.000	.000	1.990
77	1	1	1	0	1.770	1.080	.980	2.130	.340	.640	.980	7.920
77	1	1	1	1	.000	.000	.000	1.380	.000	.000	.000	1.380
77	1	3	1	0	.670	.570	.660	.660	.310	.620	.420	3.910
77	1	3	1	1	.000	.000	.000	.380	.000	.000	.000	.380
77	3	1	1	0	1.008	1.427	2.016	1.645	1.046	.629	1.802	9.573
77	3	1	1	1	.000	.000	.000	2.426	.000	.000	.000	2.426
77	3	3	1	0	2.443	1.067	.608	1.208	.541	.420	.639	6.926
77	3	3	1	1	.000	.000	.000	2.249	.000	.000	.000	2.249
77	5	1	1	0	2.502	2.639	1.087	1.593	1.048	.320	.762	9.951
77	5	1	1	1	.000	.000	.000	2.342	.000	.000	.000	2.342
77	5	3	1	0	2.389	1.215	1.032	1.431	.938	.203	.408	7.616
77	5	3	1	1	.000	.000	.013	2.166	.000	.000	.000	2.179
78	1	1	1	0	4.840	1.460	.450	.520	.510	.000	.000	7.780
78	1	1	1	1	.000	.000	.000	1.540	.000	.000	.000	1.540
78	1	3	1	0	1.870	.580	.450	.340	.220	.000	.000	3.460
78	1	3	1	1	.000	.000	.000	1.300	.000	.000	.000	1.300
78	3	1	1	0	2.277	2.299	.910	.828	.549	.000	.000	6.863
78	3	1	1	1	.000	.000	.000	1.696	.000	.000	.000	1.696
78	3	3	1	0	1.590	1.407	.886	.227	.470	.000	.000	4.580
78	3	3	1	1	.000	.000	.000	2.688	.000	.000	.000	2.688
78	5	1	1	0	3.294	1.215	.271	.272	.244	.015	.000	5.311
78	5	1	1	1	.000	.000	.000	.729	.000	.000	.000	.729
78	5	3	1	0	3.018	1.724	.380	.409	.434	.007	.000	5.972
78	5	3	1	1	.000	.000	.000	1.819	.000	.000	.000	1.819
79	1	1	1	0	.750	2.010	.760	.420	.760	.000	.000	4.700

TILE AND SURFACE FLOW

TABLE B1 (continued).—Monthly Tile Flow and/or Surface Runoff by Plots and Years (Rainfall and Irrigation) (1973-80).

1	2	3	4	5	6	7	8	9	10	11	12	13
79	1	1	1	1	000	000	000	440	1 310	000	000	1 750
79	1	3	1	0	990	1 870	810	320	620	000	000	4 610
79	1	3	1	1	000	000	000	540	1 500	000	000	2 040
79	3	1	1	0	1 027	2 104	1 638	000	000	000	000	4 769
79	3	1	1	1	000	000	000	863	000	000	000	863
79	3	3	1	0	1 264	2 468	1 116	000	000	000	000	4 848
79	3	3	1	1	000	000	000	863	000	000	000	863
79	5	1	1	0	1 640	2 837	1 265	462	401	000	000	6 605
79	5	1	1	1	000	000	001	567	863	000	000	1 430
79	5	3	1	0	1 324	2 758	1 265	618	953	000	000	6 918
79	5	3	1	1	000	000	000	760	939	000	000	1 699
80	1	1	1	0	1 830	650	000	000	000	000	000	2 480
80	1	1	1	1	000	000	000	2 330	000	000	000	2 330
80	1	3	1	0	2 280	600	000	160	000	000	000	3 040
80	1	3	1	1	000	000	000	1 600	000	000	000	1 600
80	3	1	1	0	833	145	121	173	003	034	000	1 309
80	3	1	1	1	000	000	000	1 272	000	000	000	1 272
80	3	3	1	0	1 153	189	059	160	025	006	000	1 592
80	3	3	1	1	000	000	000	1 074	000	000	000	1 074
80	5	1	1	0	2 103	1 444	199	506	065	082	000	4 399
80	5	1	1	1	000	000	000	1 060	000	000	000	1 060
80	5	3	1	0	1 625	534	050	278	033	007	000	2 527
80	5	3	1	1	000	000	000	739	000	000	000	739

APPENDIX C
CROP YIELDS

TABLE C1.—Crop Yields and Plant Populations by Plots and Years (1962-80).

1	2	3	4	5	6	7	8	9	10	11	12
1	65	1	1	1.9	0	1	76	3	4	49.9	0
1	65	1	2	3.5	0	1	76	4	1	56 1	0
1	65	1	3	6 1	0	1	76	4	2	54 9	0
1	65	1	4	3 5	0	1	76	4	3	45 8	0
1	65	2	1	50 0	0	1	76	4	4	47.4	0
1	65	2	2	44.9	0	1	76	5	1	51.4	0
1	65	2	3	41.6	0	1	76	5	2	51.9	0
1	65	2	4	36 8	0	1	76	5	3	33.6	0
1	65	3	1	54 9	0	1	76	5	4	47.0	0
1	65	3	2	48.7	0	1	77	2	1	50.9	0
1	65	3	3	48.5	0	1	77	2	2	53.2	0
1	65	3	4	47.0	0	1	77	2	3	33.5	0
1	65	4	1	52.9	0	1	77	2	4	45.6	0
1	65	4	2	46 4	0	1	77	3	1	56.4	0
1	65	4	3	51.3	0	1	77	3	2	53.4	0
1	65	4	4	48.3	0	1	77	3	3	54.7	0
1	76	2	1	44.1	0	1	77	3	4	54.6	0
1	76	2	2	52.8	0	1	77	4	1	57.5	0
1	76	2	3	40.8	0	1	77	4	2	55.8	0
1	76	2	4	51.5	0	1	77	4	3	50.3	0
1	76	3	1	58.1	0	1	77	4	4	57.7	0
1	76	3	2	51.2	0	1	77	5	1	38.6	0
1	76	3	3	54.3	0	1	77	5	2	42.4	0

Columns	Code
1 and 7	Crop 1 soybeans 2 corn 1st year 3 corn 2nd year or more 4 oats
2 and 8	Year last two digits
3 and 9	Drainage 1 no drainage 2 surface only 3 tile only (deep) 4 combination surface plus tile 5 tile only (shallow 2-inch diameter plastic tubing)
4 and 10	Replication number
5 and 11	Yield in bu/acre
6 and 12	Plant population in 100 s/acre (zeros indicate that no stand count was taken)

Note All yields are for conventional tillage For no tillage yields for corn in 1968-72 see Research Bulletin 1081 (14)

TABLE C1 (continued).—Crop Yields and Plant Populations by Plots and Years (1962-80).

1	2	3	4	5	6	7	8	9	10	11	12
1	77	5	3	50.0	0	1	80	5	2	48.2	0
1	77	5	4	46.4	0	1	80	5	3	49.2	0
1	78	2	1	43.6	0	1	80	5	4	46.0	0
1	78	2	2	43.2	0	2	62	1	1	47.5	116
1	78	2	3	41.7	0	2	62	1	2	13.7	119
1	78	2	4	31.1	0	2	62	1	3	44.7	131
1	78	3	1	50.3	0	2	62	1	4	1.6	121
1	78	3	2	51.3	0	2	62	2	1	101.8	154
1	78	3	3	45.9	0	2	62	2	2	90.3	163
1	78	3	4	44.8	0	2	62	2	3	92.2	142
1	78	4	1	48.4	0	2	62	2	4	90.8	149
1	78	4	2	54.5	0	2	62	3	1	108.8	174
1	78	4	3	46.3	0	2	62	3	2	102.1	168
1	76	4	4	51.1	0	2	62	3	3	98.9	148
1	78	5	1	38.8	0	2	62	3	4	97.5	165
1	78	5	2	38.8	0	2	62	4	1	99.3	192
1	78	5	3	49.6	0	2	62	4	2	88.8	136
1	78	5	4	39.1	0	2	62	4	3	108.1	216
1	79	2	1	25.7	0	2	62	4	4	107.1	181
1	79	2	2	44.8	0	2	67	1	1	.0	20
1	79	2	3	21.3	0	2	67	1	2	62.6	141
1	79	2	4	28.3	0	2	67	1	3	90.4	179
1	79	3	1	44.3	0	2	67	1	4	86.7	75
1	79	3	2	51.2	0	2	67	2	1	86.2	189
1	79	3	3	45.0	0	2	67	2	2	90.0	221
1	79	3	4	44.3	0	2	67	2	3	111.7	206
1	79	4	1	47.5	0	2	67	2	4	107.6	209
1	79	4	2	52.7	0	2	67	3	1	114.9	189
1	79	4	3	49.5	0	2	67	3	2	108.8	188
1	79	4	4	54.6	0	2	67	3	3	115.1	197
1	79	5	1	42.7	0	2	67	3	4	110.7	206
1	79	5	2	39.7	0	2	67	4	1	117.7	195
1	79	5	3	44.3	0	2	67	4	2	113.9	190
1	79	5	4	36.8	0	2	67	4	3	124.3	230
1	80	2	1	42.9	0	2	67	4	4	119.2	226
1	80	2	2	46.0	0	2	76	2	1	110.5	250
1	80	2	3	43.4	0	2	76	2	2	120.1	220
1	80	2	4	43.0	0	2	76	2	3	99.1	200
1	80	3	1	42.7	0	2	76	2	4	106.4	210
1	80	3	2	34.9	0	2	76	3	1	130.5	250
1	80	3	3	45.5	0	2	76	3	2	120.6	250
1	80	3	4	47.1	0	2	76	3	3	122.0	230
1	80	4	1	49.2	0	2	76	3	4	114.5	230
1	80	4	2	61.3	0	2	76	4	1	123.5	275
1	80	4	3	48.3	0	2	76	4	2	128.4	250
1	80	4	4	52.8	0	2	76	4	3	135.0	220
1	80	5	1	45.6	0	2	76	4	4	130.8	240

TABLE C1 (continued).—Crop Yields and Plant Populations by Plots and Years (1962-80).

1	2	3	4	5	6	7	8	9	10	11	12
2	76	5	1	112.3	220	2	79	4	4	126.1	218
2	76	5	2	112.8	240	2	79	5	1	116.3	159
2	76	5	3	98.6	220	2	79	5	2	119.0	173
2	76	5	4	101.9	174	2	79	5	3	117.6	189
2	77	2	1	66.4	183	2	79	5	4	111.5	159
2	77	2	2	98.2	161	2	80	2	1	152.3	206
2	77	2	3	104.2	255	2	80	2	2	143.9	206
2	77	2	4	90.0	196	2	80	2	3	151.6	206
2	77	3	1	119.1	251	2	80	2	4	152.8	206
2	77	3	2	120.2	233	2	80	3	1	147.8	206
2	77	3	3	116.3	283	2	80	3	2	156.7	206
2	77	3	4	143.3	260	2	80	3	3	157.0	206
2	77	4	1	112.6	235	2	80	3	4	144.8	206
2	77	4	2	141.9	249	2	80	4	1	155.0	206
2	77	4	3	131.6	255	2	80	4	2	147.6	206
2	77	4	4	150.5	270	2	80	4	3	153.5	206
2	77	5	1	43.2	174	2	80	4	4	142.6	206
2	77	5	2	103.3	211	2	80	5	1	142.3	206
2	77	5	3	97.5	251	2	80	5	2	143.8	206
2	77	5	4	127.4	240	2	80	5	3	152.6	206
2	78	2	1	116.0	267	2	80	5	4	136.9	206
2	78	2	2	128.0	302	3	63	1	1	78.1	161
2	78	2	3	121.0	288	3	63	1	2	36.9	148
2	78	2	4	116.0	259	3	63	1	3	89.8	157
2	78	3	1	138.0	298	3	63	1	4	31.4	110
2	78	3	2	163.0	308	3	63	2	1	82.5	159
2	78	3	3	128.0	319	3	63	2	2	83.8	151
2	78	3	4	131.0	285	3	63	2	3	94.3	160
2	78	4	1	139.0	300	3	63	2	4	71.6	150
2	78	4	2	167.0	310	3	63	3	1	109.1	174
2	78	4	3	133.0	302	3	63	3	2	96.9	156
2	78	4	4	151.0	294	3	63	3	3	87.9	150
2	78	5	1	117.0	318	3	63	3	4	91.5	167
2	78	5	2	106.0	294	3	63	4	1	104.4	161
2	78	5	3	132.0	290	3	63	4	2	88.9	160
2	78	5	4	99.0	263	3	63	4	3	107.5	160
2	79	2	1	48.3	53	3	63	4	4	102.5	161
2	79	2	2	60.2	69	3	64	1	1	61.3	127
2	79	2	3	71.7	104	3	64	1	2	31.7	75
2	79	2	4	67.3	58	3	64	1	3	72.3	122
2	79	3	1	136.3	212	3	64	1	4	55.4	136
2	79	3	2	126.7	199	3	64	2	1	103.6	151
2	79	3	3	122.2	178	3	64	2	2	68.6	165
2	79	3	4	115.4	159	3	64	2	3	67.5	113
2	79	4	1	136.6	197	3	64	2	4	77.1	194
2	79	4	2	131.6	205	3	64	3	1	114.4	264
2	79	4	3	134.1	242	3	64	3	2	92.8	179

TABLE C1 (continued).—Crop Yields and Plant Populations by Plots and Years (1962-80).

1	2	3	4	5	6	7	8	9	10	11	12
3	64	3	3	86.5	191	4	66	4	2	78.7	0
3	64	3	4	86.9	149	4	66	4	3	77.7	0
3	64	4	1	106.1	183	4	66	4	4	76.8	0
3	64	4	2	96.9	183	4	66	1	1	.0	0
3	64	4	3	95.4	185	4	66	1	2	.0	0
3	64	4	4	90.2	192	4	66	1	3	.0	0
3	68	1	1	26.1	64	4	66	1	4	.0	0
3	68	1	2	77.5	147	4	72	2	1	.0	0
3	68	2	1	102.8	224	4	72	2	2	.0	0
3	68	2	2	104.5	233	4	72	2	3	.0	0
3	68	3	1	114.4	245	4	72	2	4	.0	0
3	68	3	2	117.4	249	4	72	3	1	26.2	0
3	68	4	1	119.8	246	4	72	3	2	32.7	0
3	68	4	2	125.2	256	4	72	3	3	48.1	0
3	69	1	1	50.0	221	4	72	3	4	35.3	0
3	69	1	2	60.8	218	4	72	4	1	35.8	0
3	69	2	1	40.4	216	4	72	4	2	32.7	0
3	69	2	2	30.4	219	4	72	4	3	57.4	0
3	69	3	1	85.0	222	4	72	4	4	52.6	0
3	69	3	2	71.5	221	4	72	5	1	16.7	0
3	69	4	1	88.5	221	4	72	5	2	16.9	0
3	69	4	2	88.5	218	4	72	5	3	63.0	0
3	70	2	1	41.2	194	4	72	5	4	27.9	0
3	70	2	2	40.3	187	4	76	2	1	35.9	0
3	70	3	1	89.9	202	4	76	2	2	32.6	0
3	70	3	2	92.2	213	4	76	2	3	27.7	0
3	70	4	1	94.9	206	4	76	2	4	20.7	0
3	70	4	2	109.9	203	4	76	3	1	36.9	0
3	70	5	1	48.9	198	4	76	3	2	69.7	0
3	70	5	2	52.1	191	4	76	3	3	86.1	0
3	71	2	1	62.5	240	4	76	3	4	47.0	0
3	71	2	2	62.3	231	4	76	4	1	79.1	0
3	71	3	1	117.1	243	4	76	4	2	69.5	0
3	71	3	2	111.1	266	4	76	4	3	57.6	0
3	71	4	1	123.7	252	4	76	4	4	75.4	0
3	71	4	2	140.6	250	4	76	5	1	29.6	0
3	71	5	1	82.3	255	4	76	5	2	44.5	0
3	71	5	2	72.7	254	4	76	5	3	52.0	0
4	66	2	1	61.1	0	4	76	5	4	37.3	0
4	66	2	2	46.4	0	4	77	2	1	33.4	0
4	66	2	3	31.8	0	4	77	2	2	25.6	0
4	66	2	4	52.5	0	4	77	2	3	29.7	0
4	66	3	1	79.3	0	4	77	2	4	33.9	0
4	66	3	2	69.8	0	4	77	3	1	37.6	0
4	66	3	3	71.5	0	4	77	3	2	36.5	0
4	66	3	4	63.4	0	4	77	3	3	41.2	0
4	66	4	1	84.9	0	4	77	3	4	34.2	0

TABLE C1 (continued).—Crop Yields and Plant Populations by Plots and Years (1962-80).

1	2	3	4	5	6	7	8	9	10	11	12
4	77	4	1	42.7	0	4	78	3	1	97.3	0
4	77	4	2	46.1	0	4	78	3	2	91 8	0
4	77	4	3	44.4	0	4	78	3	3	101.6	0
4	77	4	4	40.6	0	4	78	3	4	87.4	0
4	77	5	1	27.7	0	4	78	4	1	104.7	0
4	77	5	2	22.3	0	4	78	4	2	100.6	0
4	77	5	3	40.8	0	4	78	4	3	99.5	0
4	77	5	4	26.8	0	4	78	4	4	98.8	0
4	78	2	1	79.8	0	4	78	5	1	74.2	0
4	78	2	2	76.0	0	4	78	5	2	69.0	0
4	78	2	3	68.0	0	4	78	5	3	84.7	0
4	78	2	4	74.9	0	4	78	5	4	86.1	0

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